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NATIONAL DAM SAFETY PROGRAM, LAKE TORINO DAM (MO 30552), MISSIS--ETC(U)
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LAKE TORINO DAM

FRANKLIN COUNTY, MISSOURI

MO 30552

**PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM**



**United States Army
Corps of Engineers**

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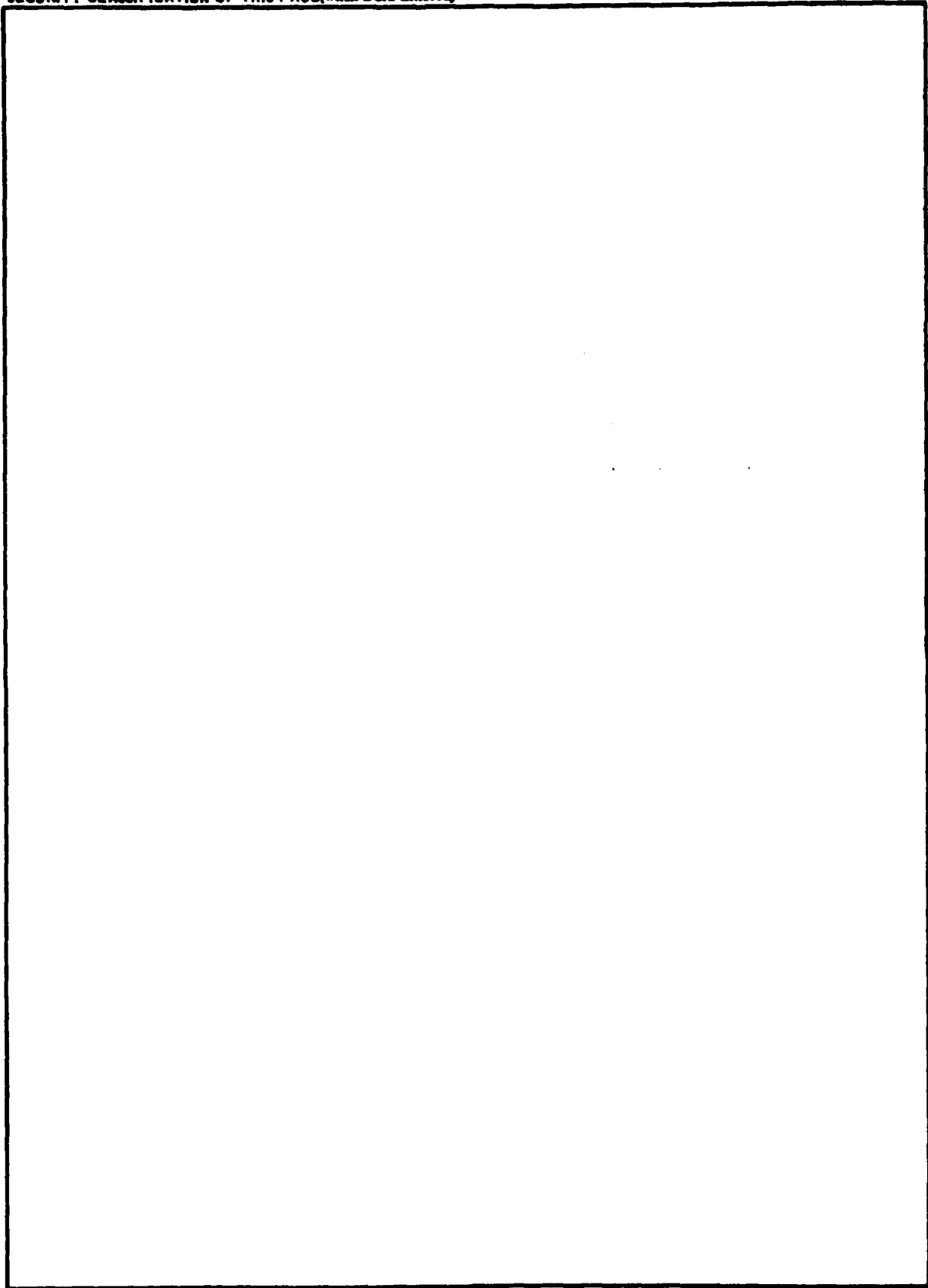
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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

SUBJECT: Lake Torino Dam (Mo. 30552)

This report presents the results of a field inspection and evaluation of Lake Torino Dam (Mo. 30552).

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency because of seepage through the embankment and the accompanying piping of soil. Piping is the removal of soil particles from the dam along with the seeping water. If allowed to continue this could develop into a serious situation in which the stability of the dam is threatened.

Because of the nature and possible consequences of this deficiency it is recommended that remedial measures be undertaken immediately to insure the safety of this dam.

SUBMITTED BY:

SIGNED
Chief, Engineering Division

25 SEP 1979

Date

APPROVED BY:

SIGNED
Colonel, CE, District Engineer

25 SEP 1979

Date

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LAKE TORINO DAM
FRANKLIN COUNTY, MISSOURI
MISSOURI INVENTORY NO. 30552

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Prepared By
Anderson Engineering, Inc., Springfield, Missouri
Hanson Engineers, Inc., Springfield, Illinois

Under Direction Of
St. Louis District, Corps of Engineers

For
Governor of Missouri

September 1979

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam: Lake Tornio Dam
State Located: Missouri
County Located: Franklin
Stream: Unnamed Tributary to Little Calvey
Creek
Date of Inspection: 25 June 1979

Lake Torino Dam was inspected by an interdisciplinary team of engineers from Anderson Engineering, Inc. of Springfield, Missouri and Hanson Engineers, Inc. of Springfield, Illinois. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers, and they have been developed with the help of several Federal and State agencies, professional engineering organizations, and private engineers. Based on these guidelines, the St. Louis District, Corps of Engineers has determined that this dam is in the high hazard potential classification, which means that loss of life and appreciable property loss could occur if the dam fails. The estimated damage zone extends approximately 3 miles downstream of the dam. Located within this zone are five to seven buildings. The dam is in the small size classification, since it is greater than 25 ft high but less than 40 ft high, and the maximum storage capacity is greater than 50 ac-ft but less than 1000 ac-ft.


Our inspection and evaluation indicates that the combined spillways do meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The combined spillways will pass 57 percent of the Probable Maximum Flood without overtopping. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The guidelines require that a dam of small size with a high downstream hazard potential pass 50 to 100 percent of the PMF. Considering the small size of the dam, the low storage impoundment capacity of the reservoir and the large floodplain downstream, 50 percent of the PMF

has been determined to be the appropriate spillway design flood. The 100-year frequency flood will not overtop the dam. The 100-year flood is one that has a 1 percent chance of being exceeded or equaled in any given year.

Deficiencies visually observed by the inspection team were: (1) erosion at the contacts of the dam with the north and south abutments; (2) tree and brush growth along upstream and downstream faces of dam; (3) animal burrows along upstream and downstream faces; (4) a few small sloughs on upstream face; (5) seepage areas on downstream face and wet areas at toe of dam; (6) debris and brush around intake to primary spillway; (7) outlet channel of primary spillway overgrown with trees and brush; and (8) swale at south end of dam. Another deficiency was the lack of seepage and stability analysis records.


A seepage area at Station 2+70 is carrying soil particles and is considered especially serious. Increased transportation of soil particles could lead to piping failure of the embankment. Remedial measures will be required.

It is recommended that the owners take the necessary action in the near future to correct the deficiencies reported herein. A detailed discussion of these deficiencies is included in the following report.


Steve Brady, P.E. (AEI)


Dave Daniels, P.E. (HEI)


Tom Beckley, P.E. (AEI)


Nelson Morales, P.E. (HEI)

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
LAKE TORINO - ID No. 30552

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SECTION 1 - PROJECT INFORMATION

1.1 GENERAL:

A. Authority:

The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection be made of Lake Torino Dam in Franklin County, Missouri.

B. Purpose of Inspection:

The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and a visual inspection in order to determine if the dam poses hazards to human life or property.

C. Evaluation Criteria:

Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, "Recommended Guidelines for Safety Inspection of Dams, Appendix D." These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT:

A. Description of Dam and Appurtenances:

Lake Torino Dam is an earth fill structure approximately 38.5 ft high and 570 ft long at the crest. The appurtenant works consist of a 10 in. diameter steel pipe primary spillway located near the center of the dam and a grass-covered earth emergency spillway located at the north end of the dam. Sheet 3 of Appendix A shows a plan, profile and typical section of the embankment.

B. Location:

The dam is located in the east central part of Franklin County, Missouri on a tributary of Little Calvey Creek. The dam and lake are within the Lonedell, Missouri 7.5 minute quadrangle sheet (Section 20, T42N, R2E - latitude 38° 21.74'; longitude 90° 49.63'). Sheet 2 of Appendix A shows the general vicinity.

C. Size Classification:

With an embankment height of 38.5 ft and a maximum storage capacity of approximately 138 acre-ft, the dam is in the small size category.

D. Hazard Classification:

The St. Louis District, Corps of Engineers has classified this dam as a high hazard dam. The estimated damage zone extends approximately 3 miles downstream of the dam. Located within this zone are five to seven buildings.

E. Ownership:

The dam is owned by Mr. Arthur Meyer. The owner's address is 801 Richson, Potosi, Missouri 63664.

F. Purpose of Dam:

The dam was constructed primarily for recreational purposes, although some flood protection is also provided.

G. Design and Construction History:

Although some design and construction assistance was reportedly provided by the Soil Conservation Service, no plans or records were available. The dam was constructed by Mr. Melvin Gunther (now deceased) in 1969. Material for the dam was reportedly obtained from the lake area and an upland area north of the dam. A key trench and clay core was provided for the dam according to the owner. The key trench and core are reported to be 14 ft wide. No modifications have been made to the dam.

H. Normal Operating Procedures:

Normal flows are passed by a steel pipe primary spillway, whereas a grassed emergency spillway would come into operation for major floods. Information indicates that the emergency spillway is used about once a year, and the dam has never been overtopped.

1.3 PERTINENT DATA:

Pertinent data about the dam, appurtenant works, and reservoir are presented in the following paragraphs. Sheet 3 of Appendix A presents a plan, profile and typical section of the embankment.

A. Drainage Area:

The drainage area for this dam, as obtained from the U.S.G.S. quad sheet, is approximately 64 acres.

B. Discharge at Dam Site:

- (1) All discharge at the dam site is through uncontrolled spillways.
- (2) Estimated Total Spillway Capacity at Maximum Pool (Top of Dam - El. 102.7): 355 cfs
- (3) Estimated Capacity of Primary Spillway: 5 cfs
- (4) Estimated Experienced Maximum Flood at Dam Site: Unknown
- (5) Diversion Tunnel Low Pool Outlet at Pool Elevation: Not Applicable
- (6) Diversion Tunnel Outlet at Pool Elevation: Not Applicable
- (7) Gated Spillway Capacity at Pool Elevation: Not Applicable
- (8) Gated Spillway Capacity at Maximum Pool Elevation: Not Applicable

C. Elevations:

All elevations are consistent with an assumed elevation of 100.0 for the top of the 10 in. diameter inlet pipe (see Sheet 3, Appendix A).

- (1) Top of Dam: 102.7 (Low Point); 103.1 (High Point)
- (2) Principal Spillway Crest: 99.0
- (3) Emergency Spillway Crest: 100.1
- (4) Principal Outlet Pipe Invert: 66.8
- (5) Streambed at Centerline of Dam: 64.6
- (6) Pool on Date of Inspection: 98.7
- (7) Apparent High Water Mark: None Visible
- (8) Maximum Tailwater: Unknown

- (9) Upstream Portal Invert Diversion Tunnel: Not Applicable
- (10) Downstream Portal Invert Diversion Tunnel: Not Applicable

D. Reservoir Lengths:

- (1) At Top of Dam: 1000 ft
- (2) At Principal Spillway Crest: 950 ft
- (3) At Emergency Spillway Crest: 970 ft

E. Storage Capacities:

- (1) At Principal Spillway Crest: 102 ac-ft
- (2) At Top of Dam: 138 ac-ft
- (3) At Emergency Spillway Crest: 112 ac-ft

F. Reservoir Surface Areas:

- (1) At Principal Spillway Crest: 9 ac
- (2) At Top of Dam: 10.5 ac
- (3) At Emergency Spillway Crest: 9.5 ac

G. Dam:

- (1) Type: Earth
- (2) Length at Crest: 570 ft
- (3) Height: 38.5 ft
- (4) Top Width: 13 ft
- (5) Side Slopes: Upstream 4.2:1.0 (crest to water's edge);
Downstream 2.5:1.0
- (6) Zoning: None
- (7) Impervious Core: Compacted clay (14 ft wide - information by owner)

(8) Cutoff: Shallow core trench (14 ft wide - information by owner)

(9) Grout Curtain: None

H. Diversion and Regulating Tunnel:

(1) Type: None

(2) Length: Not Applicable

(3) Closure: Not Applicable

(4) Access: Not Applicable

(5) Regulating Facilities: None

I. Spillway:

I.1 Principal Spillway:

(1) Location: Center of Dam

(2) Type: 10 in. diameter steel pipe

I.2 Emergency Spillway:

(1) Location: North abutment

(2) Type: Grass-covered earth swale

J. Regulating Outlets:

There are no dewatering facilities provided for the dam.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN:

Although it was reported that the Soil Conservation Service had provided some design and construction assistance for Lake Torino Dam, no design computations or reports could be located. No documentation of construction inspection records have been obtained. To our knowledge, there are no documented maintenance data.

A. Surveys:

No information regarding pre-construction surveys was able to be obtained. Sheet 3 of Appendix A presents a plan, profile and cross section of the dam from survey data obtained during the site inspection. The top of the inlet of the 10 in. diameter steel pipe primary spillway was used as a site datum of assumed elevation 100.00 (see Sheet 3, Appendix A). It is estimated that this site datum approximately corresponds to mean sea level elevation 675.

B. Geology and Subsurface Materials:

The site is located near the northeastern limit of the Ozarks geologic region of Missouri. The Ozarks are characterized topographically by hills, plateaus and deep valleys. The most common bedrock types are dolomite, sandstone and chert. The Missouri Geological Survey indicates that the bedrock in the site area consists primarily of the Jefferson City formation of the Canadian Series in the Ordovician System. The Jefferson City formation is composed principally of light brown to brown medium to fine crystalline dolomite and argillaceous dolomite. The publication "Caves of Missouri" indicates that while numerous caves are known to exist in Franklin County, they are densely clustered in the south-central part of the county, at least 15 miles from the site.

The "Geologic Map of Missouri" indicates a normal fault passing about 6 miles northwest of the site in a north-south direction. The Missouri Geological Survey has indicated that the faults in this area are generally considered to be inactive and have been for several hundred million years.

The soils overlying the Jefferson City formation are of the Union-Fullerton-McGirk Soil Association, and consist of a veneer of clayey residual material with a thin cover of loess. The loessial deposits in upland areas are generally about 5 ft thick.

The Union soils are the most extensive soils in this association. These soils consist of a light brown to brown silty clay derived from weathering of dolomitic limestone. Shallow auger probes into the embankment indicated the dam to consist of a brown silty clay to clayey silt material. This type of soil is considered to be moderately erodible.

C. Foundation and Embankment Design:

No foundation and embankment design information was available. Seepage and stability analyses as required by the guidelines were not able to be obtained. The owner indicated that a key trench (cutoff) and clay core were built into the embankment, each about 14 ft wide. The depth of the key trench is unknown. No internal drainage features are known to exist. No construction inspection test results have been obtained.

D. Hydrology and Hydraulics:

No hydrologic and hydraulic design computations for Lake Torino were available. Based on a field check of spillway dimensions and embankment elevations, and a check of the drainage area on U.S.G.S. quad sheets, hydrologic analyses using U.S. Corps of Engineers guidelines were performed and appear in Appendix C, Sheets 1 to 8. It was concluded that the structure will pass 57 percent of the Probable Maximum Flood without overtopping. The 100-year frequency flood will not overtop the dam.

E. Structure:

The only appurtenant structure is the 10 in. diameter steel primary spillway pipe. No design information concerning this structure is available.

2.2 CONSTRUCTION:

No construction inspection data have been obtained.

2.3 OPERATION AND MAINTENANCE:

Normal flows are passed by the uncontrolled steel pipe primary spillway, whereas a grassed emergency spillway will come into operation for major floods. There are no regulating facilities associated with this dam, and therefore, no operating records are known to exist. The owner indicated that brush and tree growth is removed semiannually.

2.4 EVALUATION:

A. Availability:

No engineering data, seepage or stability analyses, or construction test data were available.

B. Adequacy:

The engineering data available were inadequate to make a detailed assessment of the design, construction, and operation of this structure. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

C. Validity:

To our knowledge, no valid engineering data on the design or construction of the embankment are available.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS:

A. General:

The field inspection was made on June 25, 1979. The inspection team consisted of personnel from Anderson Engineering, Inc. of Springfield, Missouri and Hanson Engineers, Inc. of Springfield, Illinois. The team members were:

Steve Brady - Anderson Engineering, Inc. (Civil Engineer)
Tom Beckley - Anderson Engineering, Inc. (Civil Engineer)
Nelson Morales - Hanson Engineers, Inc. (Hydraulic Engineer)
Dave Daniels - Hanson Engineers, Inc. (Geotechnical Engineer)

B. Dam:

The dam appears to be generally in fair condition. Some small sloughing was noted on the upstream face, and some seepage areas were observed on the downstream face. At Station 2+70 (elevation 86), a 6 in. diameter hole was observed which was passing noticeable seepage and some soil particles (see Photo No's. 9 & 10). The quantity of seepage was estimated to be about 0.5 gallons per minute. Another area at Station 2+30 (see Photo No. 11) was damp and covered with reeds, although no flow was detectable. Coloration in this wet area indicated that it is an active seepage area and possibly has carried soil particles.

Wet soft areas with reeds and cattails were observed along the contact of the embankment with the abutments (see Photo No. 8) although no seepage flows were noted. These wet areas could be attributed to poor drainage. The horizontal alignment of the embankment appears to be concave downward near the south abutment and straight toward the north abutment. The dam is fairly level across the crest, except for a small swale at the south abutment. Some cracking of the crest of the embankment was observed, but these cracks were random and not continuous, indicating that they were probably shrinkage cracks. Shallow auger probes into the embankment indicated the dam to consist of a brown silty clay to clayey silt material. Information from the owner indicated that borrow material for construction of the dam was obtained from the lake area and an upland area north of the dam.

Erosion channels are located at the contacts of the dam with the north and south abutments. Small animal burrows were observed on the upstream and downstream faces of the embankment. Small, scattered tree and brush growth was also observed on both embankment faces. Wave protection for the upstream face of the dam consists of gravel-sized rocks with some larger rock. No instrumentation (monuments, piezometers, etc.) was observed.

C. Appurtenant Structures:

C.1 Primary Spillway:

The area around the intake to the primary spillway contains debris and brush growth. The outlet channel is overgrown with trees and brush. The 10 in. diameter steel pipe appeared to be in good condition.

C.2 Emergency Spillway:

The grass-covered earth emergency spillway appeared to be in good condition. An earth berm exists to direct flows away from the embankment. Very little erosion of the emergency spillway was noted.

D. Reservoir:

The watershed is generally wooded and grass-covered, with no agricultural activity. The slopes adjacent to the reservoir are moderate, and no sloughing or serious erosion was noted.

E. Downstream Channel:

The outlet channel of the primary spillway is overgrown with trees and brush. The downstream channel is shallow, with variable slopes, and is heavily overgrown with trees and brush.

3.2 EVALUATION:

The seepage areas previously described should be investigated by an engineer experienced in the design and construction of dams. The seepage which is carrying soil particles from the hole at Station 2+70 is especially serious. Increased transportation of soil particles could lead to piping failure of the embankment. Remedial measures will be required. Subsequently, these areas should be

inspected periodically in an effort to detect future seepage. If future seepage is detected, an engineer experienced in the design and construction of dams should be contacted immediately.

Trees and brush on the dam constitute a potential seepage hazard and encourage animal burrowing. Debris and vegetation around the intake to the primary spillway can seriously restrict flood flows. The erosional areas at the dam-abutment contacts could adversely affect the stability of the embankment if not corrected. Animal burrows in the embankment can increase the possibility for seepage to develop.

The sloughing on the upstream face indicates that the erosion resistance is inadequate. The wet areas at the toe of the dam, if not corrected, may adversely affect the stability of the dam. Tree and brush growth in the outlet channel of the primary spillway could restrict flood flows. The swale at the south end of the dam crest significantly reduces the storage capacity of the reservoir.

All of these deficiencies should be corrected under the direction of an engineer experienced in the design and construction of dams.

Photographs of the dam, appurtenant structures, and the reservoir are presented in Appendix D.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES:

There are no controlled outlet works for this dam. The spillway is uncontrolled, so that the pool is normally controlled by rainfall, runoff and evaporation.

4.2 MAINTENANCE OF DAM:

The owner indicated that the grass is mowed twice a year. The grass and weeds were about 3 ft high on the day of inspection.

4.3 MAINTENANCE OF OPERATING FACILITIES:

There are no operating facilities for this dam.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT:

The inspection team is unaware of any existing warning system for this dam.

4.5 EVALUATION:

The seepage areas at Stations 2+30 and 2+70 on the downstream face should be investigated by an engineer experienced in the design and construction of dams. Remedial measures will be required. Subsequently, these areas should be inspected periodically to detect any further seepage. Increased transportation of soil particles from the hole at Station 2+70 could lead to a piping failure of the embankment.

Trees and brush on the embankment, erosional areas, animal burrows, sloughing on the upstream face of the dam, vegetation and debris in the intake area and outlet channel of the primary spillway, and the swale at the south end of the dam crest are serious deficiencies. These deficiencies should be corrected under the direction of an experienced engineer to avoid creating an unsafe condition.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES:

A. & B. Design and Experience Data:

The hydraulic and hydrologic analyses were based on: (1) a field survey of spillway dimensions and embankment elevations, and (2) an estimate of the pool and drainage areas from the U.S.G.S. quad sheet. Mr. Meyer indicated that the emergency spillway is used occasionally, recently having about 4 in. of water over the spillway. It is reported that the dam has never been overtopped. Our hydrologic and hydraulic analyses using U. S. Army Corps of Engineers guidelines appear in Appendix C.

C. Visual Observations:

The inlet to the primary spillway contains vegetation and debris. Tree and brush growth exists in the outlet channel of the primary spillway. A swale at the south end of the dam significantly reduces the possible storage capacity of the reservoir.

D. Overtopping Potential:

Based on the hydrologic and hydraulic analysis presented in Appendix C, the combined spillways will pass 57 percent of the Probable Maximum Flood. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The recommended guidelines from the Department of the Army, Office of the Chief of Engineers, require that this structure (small size with high downstream hazard potential) pass 50 percent to 100 percent of the PMF, without overtopping. Considering the small size of the dam, the low storage impoundment capacity of the reservoir and the large floodplain downstream, 50 percent of the PMF has been determined to be the appropriate spillway design flood. The structure will pass a 100-year frequency flood without overtopping.

The routing of 50 percent of the PMF through the spillways and dam indicates that the dam will not be overtopped. The maximum discharge capacity of the spillways is 355 cfs.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY:

A. Visual Observations:

Observed features which could adversely affect the structural stability of this dam are discussed in Sections 3.1B and 3.2.

B. Design and Construction Data:

No design and construction data for the foundation and embankment were available. Seepage and stability analyses comparable to the requirements of the guidelines were not available, which constitutes a deficiency which should be rectified.

C. Operating Records:

No operating records have been obtained.

D. Post-Construction Changes:

The owner reported that there had been no post-construction changes to the dam.

E. Seismic Stability:

The structure is located in seismic zone 2, immediately adjacent to zone 1. An earthquake of this magnitude would not generally be expected to cause severe structural damage to a well constructed earth dam of this size. However, it is recommended that the prescribed seismic loading for this zone be applied in stability analyses performed for this dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT:

This Phase I inspection and evaluation should not be considered as being comprehensive since the scope of work contracted for is far less detailed than would be required for an in-depth evaluation of dams. Latent deficiencies, which might be detected by a totally comprehensive investigation, could exist.

A. Safety:

The embankment is generally in fair condition. Several items were noted during the visual inspection which should be investigated further, corrected and controlled. These items are: (1) seepage areas on downstream face and wet areas at toe of dam; (2) erosion at the contacts of the dam with the north and south abutments; (3) small tree and brush growth along upstream and downstream faces; (4) animal burrows along upstream and downstream faces of embankment; (5) few small sloughs on upstream face of dam; (6) debris and brush around intake to primary spillway; (7) outlet channel of primary spillway overgrown with trees and brush; and (8) swale at south end of dam.

The dam will be overtopped by flows in excess of 57 percent of the Probable Maximum Flood. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

B. Adequacy of Information:

The conclusions in this report were based on the performance history as related by others, and visual observation of external conditions. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses comparable to the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

C. Urgency:

The remedial measures recommended in paragraph 7.2 should be accomplished in the near future. If the deficiencies listed in paragraph A are not corrected, and if good maintenance is not provided, the embankment condition will deteriorate and possibly could become serious in the future. The seepage area at Station 2+70 is especially serious.

D. Necessity for Phase II:

Based on the result of the Phase I inspection, no Phase II inspection is recommended.

E. Seismic Stability:

The structure is located in seismic zone 2, immediately adjacent to zone 1. An earthquake of this magnitude would not generally be expected to cause severe structural damage to a well constructed earth dam of this size. However, it is recommended that the prescribed seismic loading for this zone be applied in any stability analyses performed for this dam.

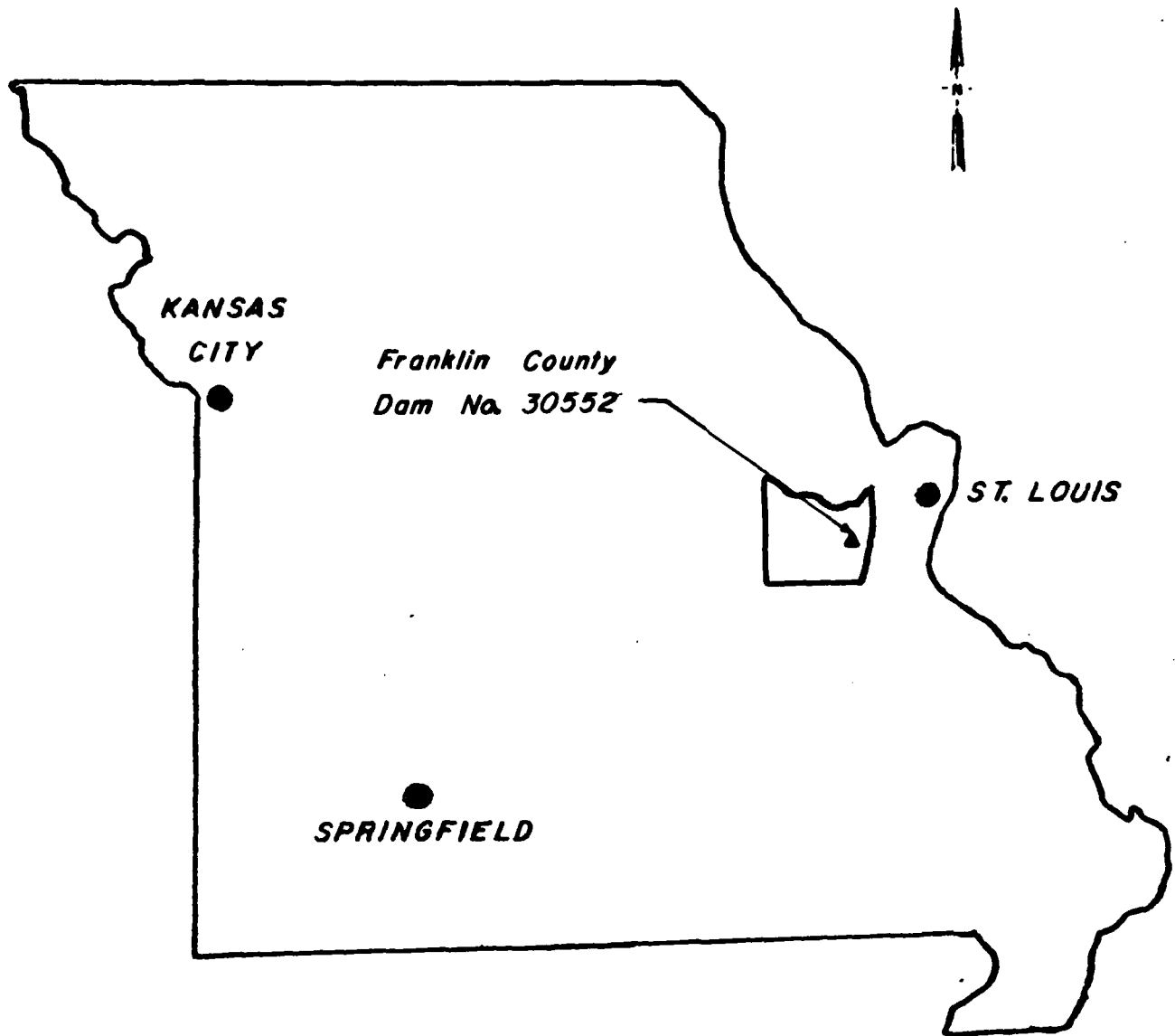
7.2 REMEDIAL MEASURES:

The following remedial measures and maintenance procedures are recommended. All remedial measures should be performed under the guidance of a professional engineer experienced in the design and construction of dams.

- (1) The spillway should be protected to prevent erosion.
- (2) Seepage and stability analyses comparable to the requirements of the recommended guidelines should be performed by an engineer experienced in the construction of dams.
- (3) The seepage areas at Stations 2+30 and 2+70 on the downstream face of the dam should be investigated by an engineer experienced in the design and construction of dams. Remedial measures will be required. Subsequently, these areas should be inspected periodically in an effort to detect future seepage. If seepage recurs, then an engineer experienced in the design and construction of dams should be contacted immediately. Increased transportation of soil particles from the hole at Station 2+70 could lead to a piping failure of the embankment.
- (4) Erosion at the contacts of the dam with the north and south abutments should be repaired and maintained.
- (5) Animal burrows on the embankment should be repaired.

- (6) Trees and brush as noted previously should be removed. This should be done under the guidance of a professional engineer experienced in the design and construction of dams. Indiscriminate clearing methods could jeopardize the safety of the dam. Brush and tree growth should then be removed on an annual basis.
- (7) The small sloughs on the upstream face should be repaired, and additional erosion protection (riprap) should be provided.
- (8) Positive drainage should be provided for the wet areas along the toe of the dam. These areas should periodically be monitored to detect possible seepage problems.
- (9) The swale at the south end of the dam crest should be filled with compacted clayey material.
- (10) A detailed inspection of the dam should be made periodically by an engineer experienced in the design and construction of dams.

APPENDIX A



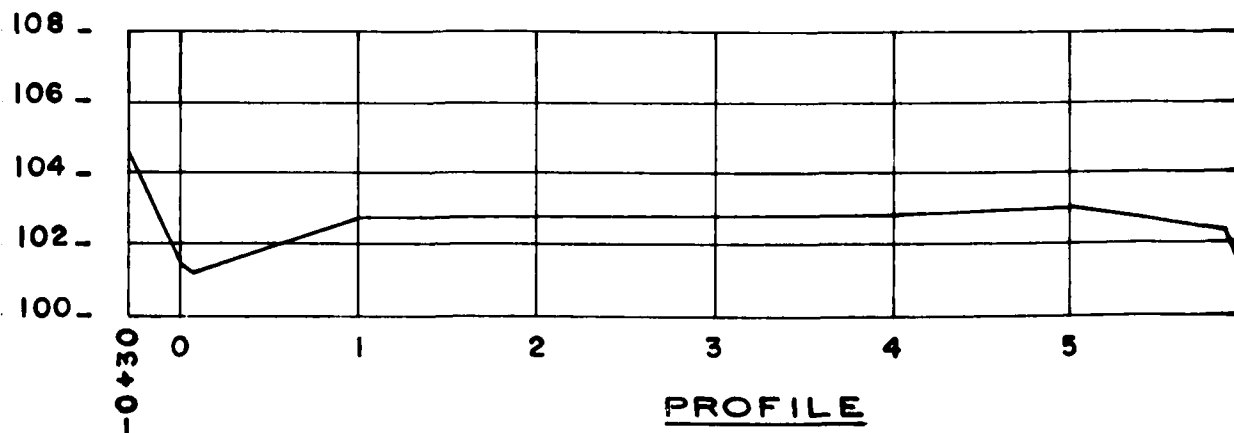
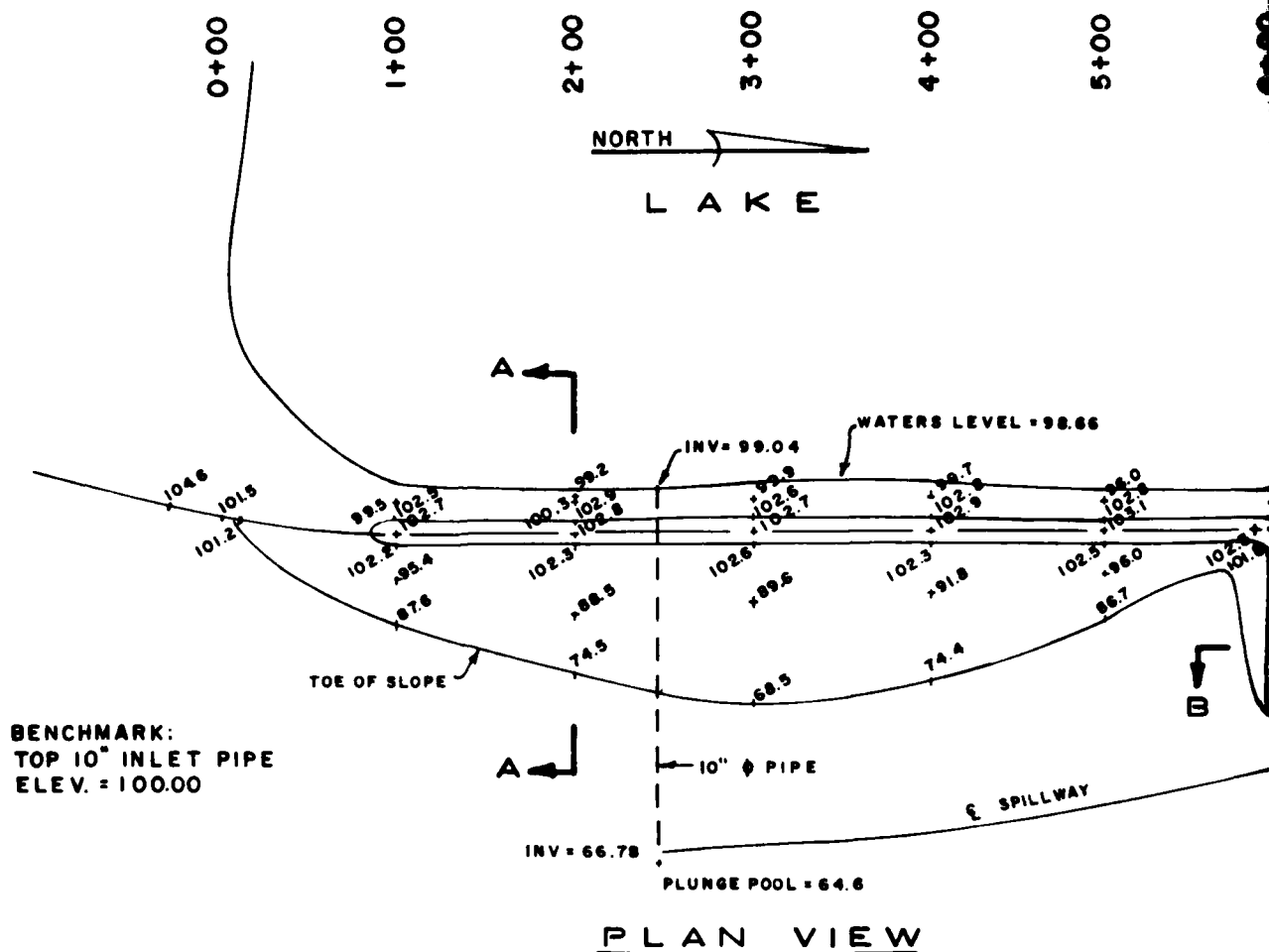
LOCATION MAP

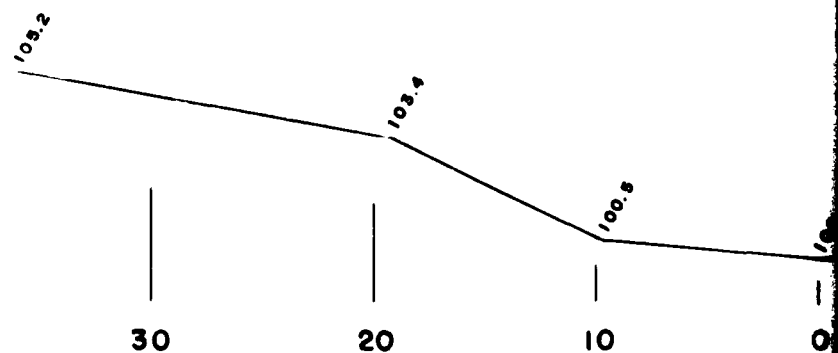
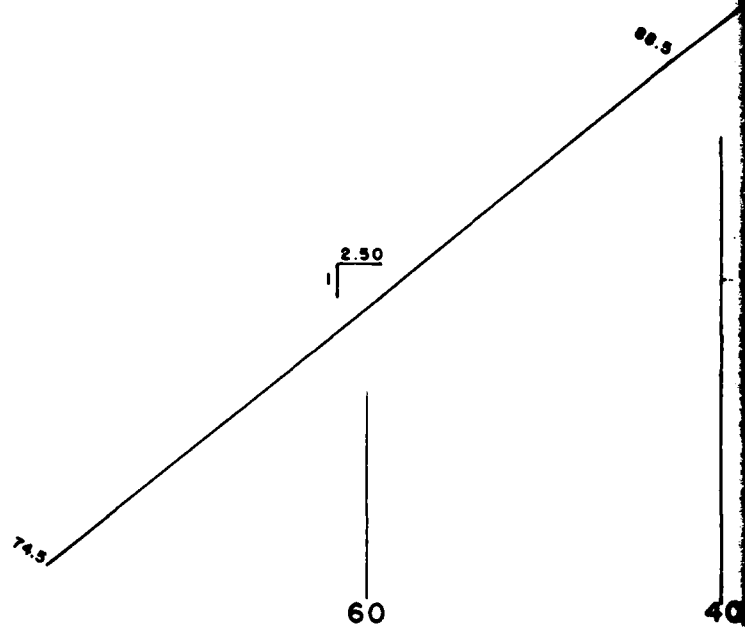
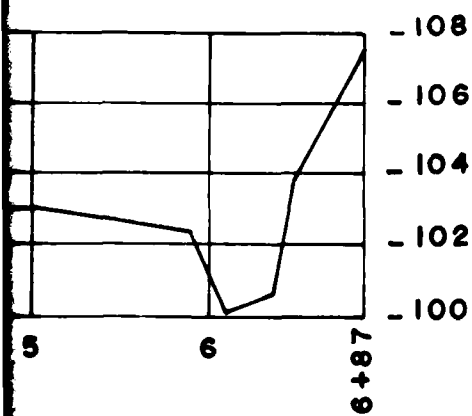
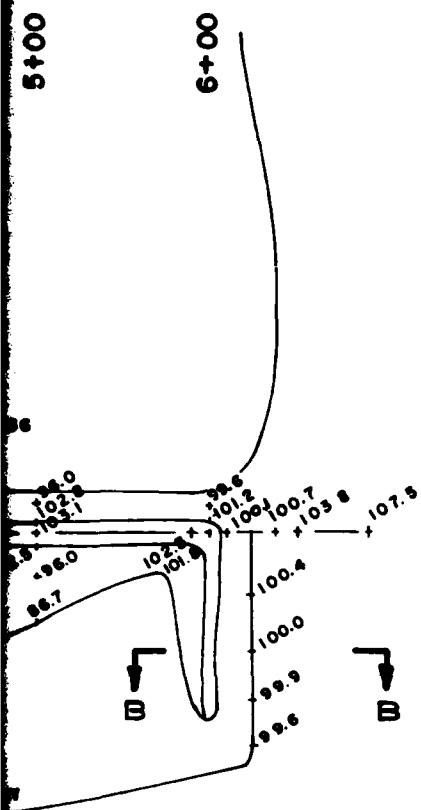
SHEET 1 OF APPENDIX A



SITE VICINITY MAP

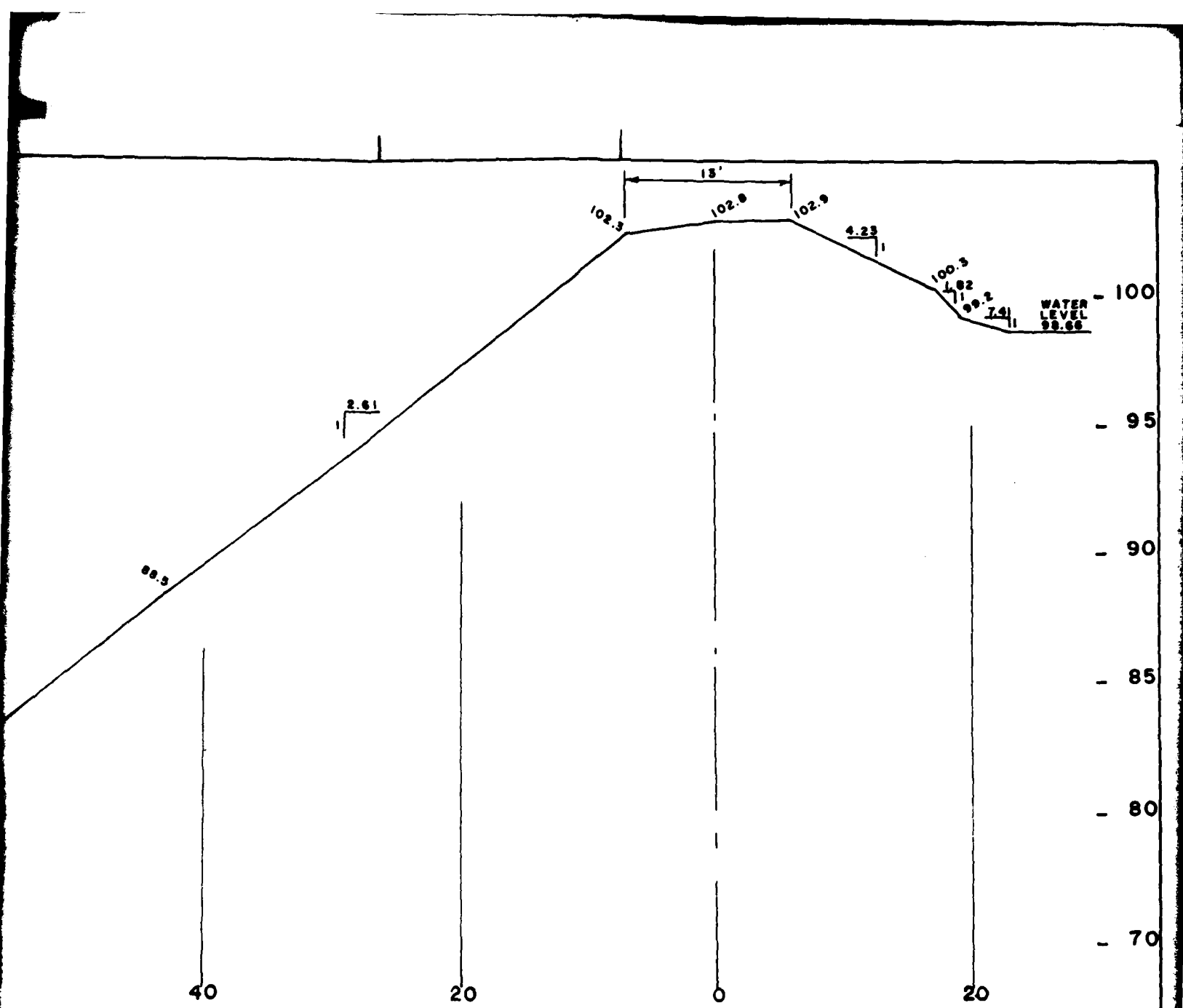
Sheet 2 Appendix A



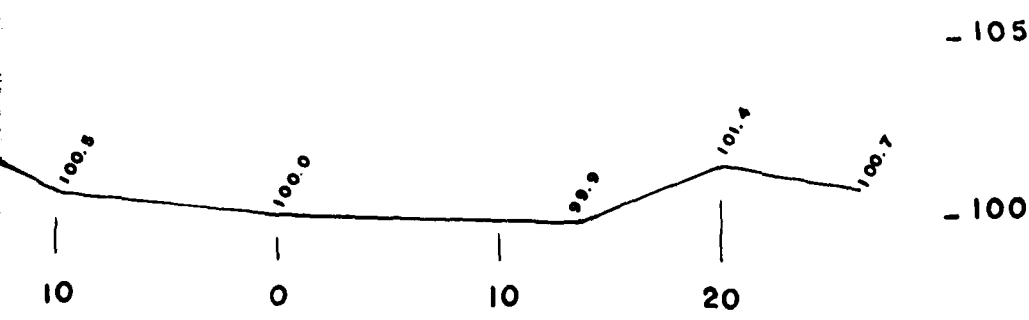


2

SECTION B-B 60



SECTION A-A STA 2+00



SECTION B-B 68' RT. STA 6+22

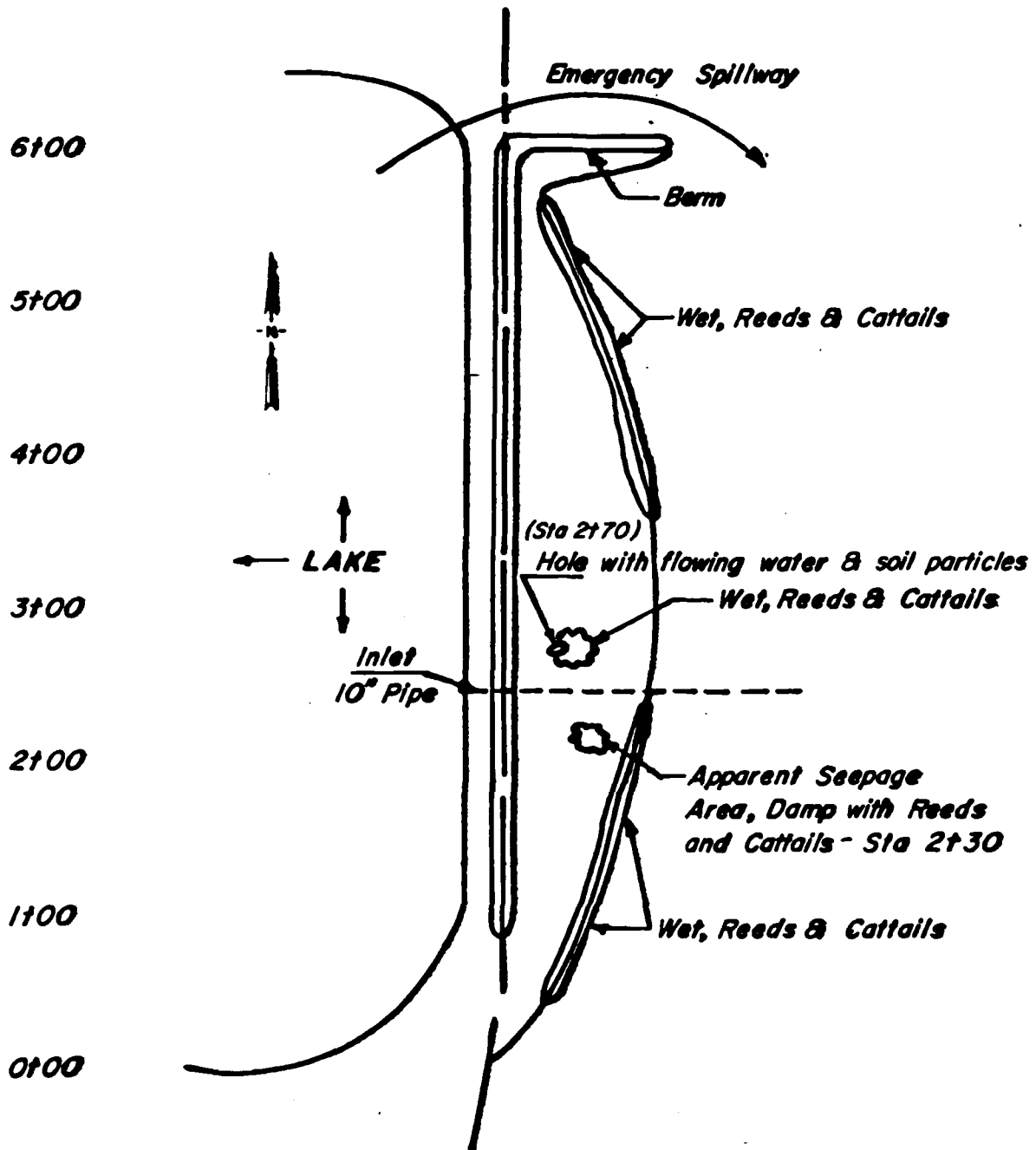
ANDERSON ENGINEERING, INC.
730 NORTH BENTON AVENUE
SPRINGFIELD, MISSOURI 65802

LAKE TORINO DAM

MO. No. 30552

PLAN & PROFILE

FRANKLIN COUNTY, MO.



DRAWN DER
 CHECKED DED
 DATE 7-19-79
 JOB NO. 7951



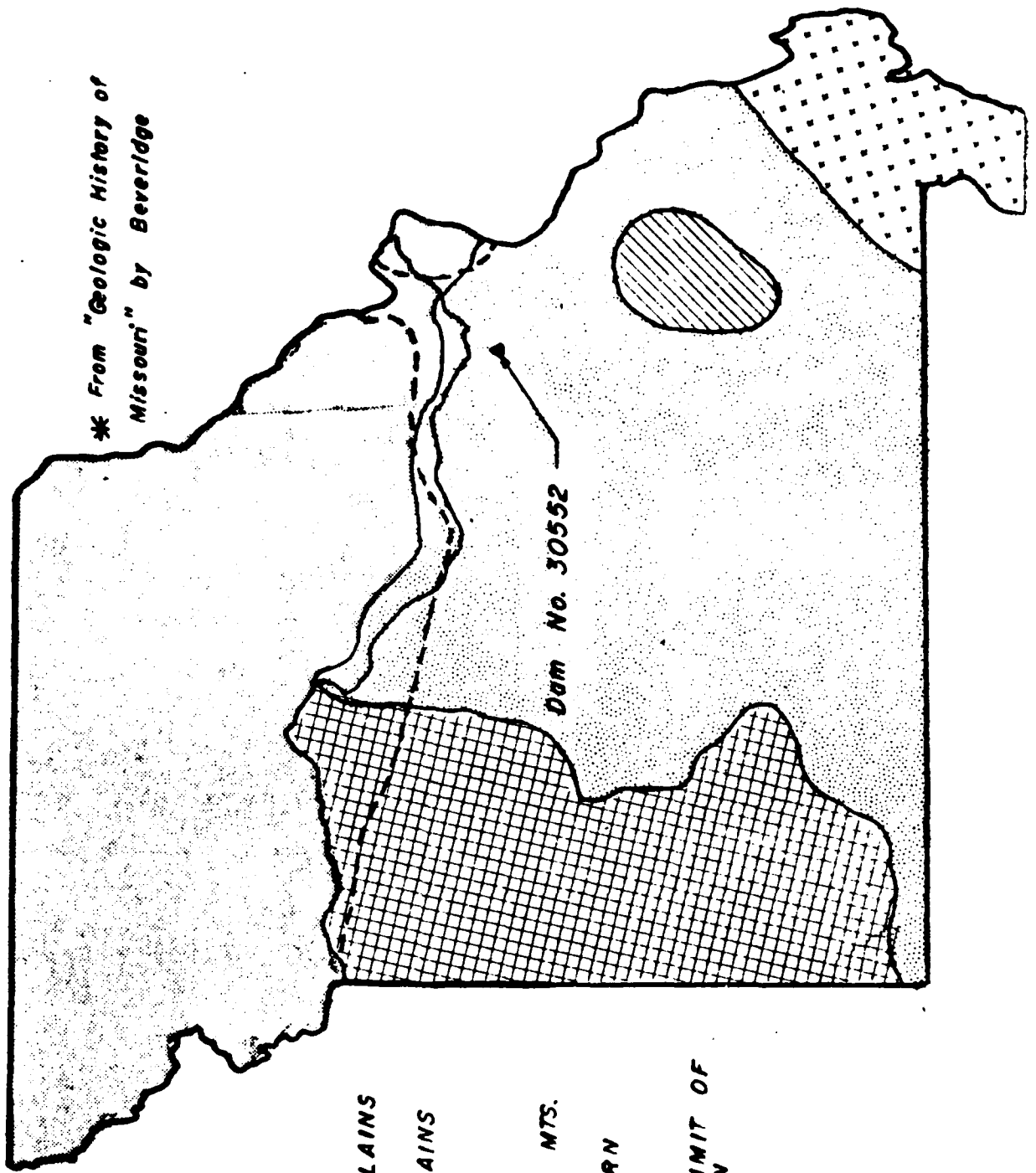
SPRINGFIELD ILL. - PEORIA ILL.

Plan Sketch
Inspection Observations
Sheet 4 Appendix A

APPENDIX B

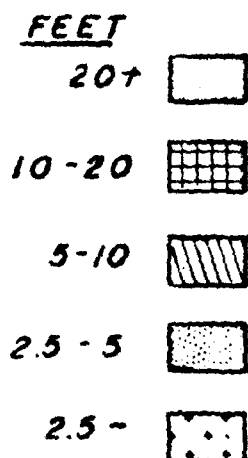
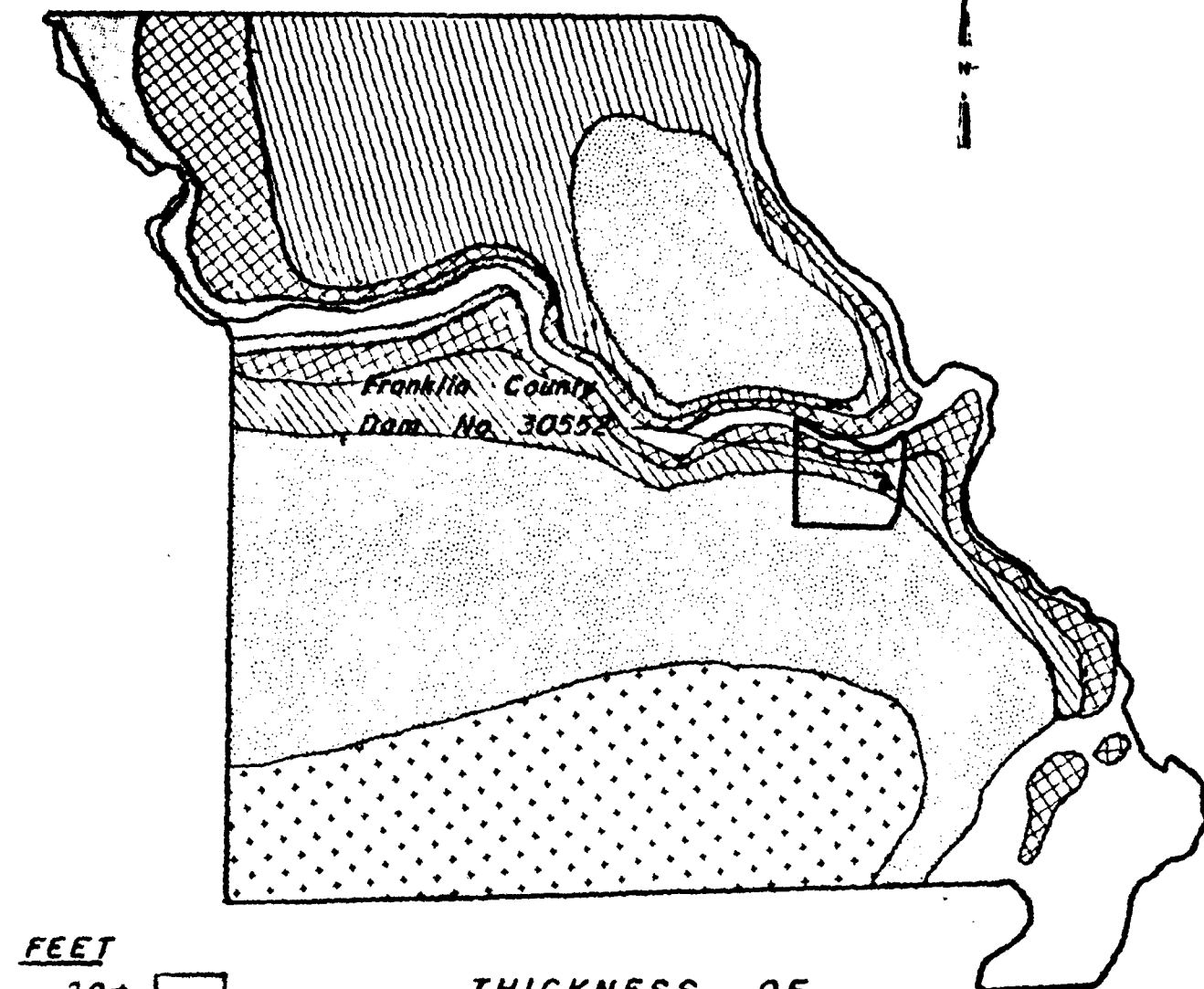
MAJOR GEOLOGIC REGIONS OF MISSOURI

* From "Geologic History of Missouri" by Beveridge



- GLACIATED PLAINS
- WESTERN PLAINS
- OZARKS
- ST. FRANCOIS MTS.
- SOUTHEASTERN LOWLANDS
- SOUTHERN LIMIT OF GLACIATION

* From "Soils of Missouri"

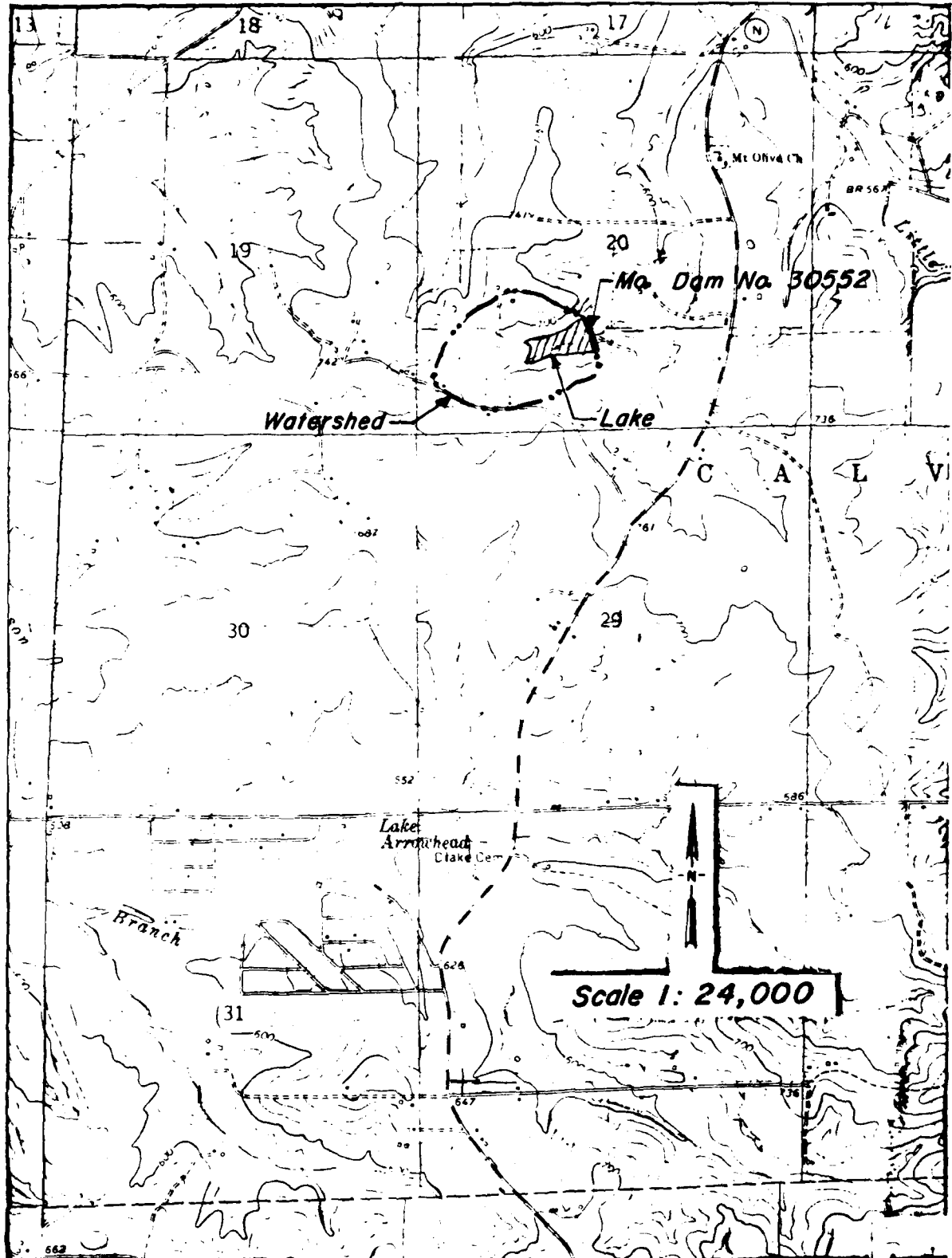


THICKNESS OF
LOESSIAL DEPOSITS

SHEET 2 OF APPENDIX B

APPENDIX C

From Lonedell 7.5' Quad



LAKE AND WATERSHED MAP

Sheet 1 Appendix C

HYDRAULIC AND HYDROLOGIC DATA

Design Data: From Field Measurements and Computations

Experience Data: No records are available. The owner, Mr. Arthur Meyer, indicated that the dam has never been overtopped and that the emergency spillway operates about once a year. He also said that in April this year the water was about 4 in. above the crest elevation of the emergency spillway. On the day of the inspection, there was no indication of high water marks or overtopping. No significant erosion was found in the emergency spillway outlet channel.

Visual Inspection: At the time of the inspection, the pool level was approximately 0.38 ft below normal pool.

Overtopping Potential: Flood routings were performed to determine the overtopping potential. The watershed and the reservoir surface areas were obtained by planimeter from the U.S.G.S. Lonedell, Missouri 7.5 minute quadrangle map. The storage volume was developed from this datum. A 5 minute interval unit graph was developed for this watershed, which resulted in a peak inflow of 484 c.f.s. and a time to peak of 6 minutes. Application of the probable maximum precipitation minus losses results in a flood hydrograph peak inflow of 1695 c.f.s. Rainfall distribution for the 24 hour storm was according to EM 1110-2-1411.

Based on our analyses, the combined spillways will pass 57 percent of the Probable Maximum Flood (PMF). The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The recommended guidelines from the Department of the Army, Office of the Chief of Engineers, require that the structure (small size with high downstream hazard potential) pass 50 to 100 percent of the PMF, without overtopping. Considering the small volume of water impounded, the small height of the dam, and the large floodplain downstream, 50 percent of the PMF has been determined to be the appropriate spillway design flood.

The routing of 50 percent of the PMF through the spillway and dam indicates that the dam will not be overtopped. The maximum discharge capacity of the combined spillways is 355 c.f.s. Analysis of the data indicates that the 100-year frequency flood will not overtop the dam. The computer input, output and hydrographs for 50 percent of the PMF are presented on Sheets 5, 6 and 7 of Appendix C.

OVERTOPPING ANALYSIS FOR LAKE TORINO DAM

INPUT PARAMETERS

1. Unit Hydrograph - SCS Dimensionless - Flood Hydrograph Package (HEC-1); Dam Safety Version Was Used.

Hydraulic Inputs Are As Follows:

- a. Twenty-four Hour Rainfall of 25.6 Inches
For 200 Square Miles - All Season Envelope
- b. Drainage Area = 64 Acres; = 0.10 Sq. Miles
- c. Travel Time of Runoff 0.010 Hrs.; Lag Time 0.06 Hrs.
- d. Soil Conservation Service Soil Group C
- e. Soil Conservation Service Runoff Curve No. 88 (AMC III)
- f. Proportion of Drainage Basin Impervious 0.14

2. Spillways

- a. Primary Spillway: 10 in. I.D. Steel Pipe

- b. Emergency Spillway: Trapezoidal Cut (Seeded)
4.2:1
Length 26 Ft.; Side Slopes 5.5:1; C = 2.7

- c. Dam Overflow

Length 570 Ft.; Crest El. 102.7; C = 3.0

3. Spillway and Dam Rating:

Curve Prepared by Hanson Engineers. Data Provided To Computer on Y4 and Y5 Cards. The discharge through the low spot at the right abutment was not considered in computing the rating curve

Formula Used:

Primary Spillway: Pipe with Inlet Control Charts
Emergency Spillway: $Q = CLH^{1.5}$

Note: Time of Concentration From Equation $T_c = \left(\frac{11.9 L^3}{H} \right)^{.385}$
California Culvert Practice, California Highways and Public Works, Sept. 1942.

SUMMARY OF DAM SAFETY ANALYSIS

1. Unit Hydrograph
 - a. Peak - 484 c.f.s.
 - b. Time to Peak 6 Min.
2. Flood Routings Were Computed by the Modified Puls Method
 - a. Peak Inflow
50% PMF 848 c.f.s.; 100% PMF 1695 c.f.s.
 - b. Peak Elevation
50% PMF 102.55 100% PMF 103.32
 - c. Portion of PMF That Will Reach Top of Dam
57 %; Top of Dam Elev. 102.7 Ft.
3. Computer Input and Output Data are shown on Sheets 5 and 6 of this Appendix.

A OVERTOPPING ANALYSIS FOR LAKE TORINO DAM (B29)
 A STATE ID NO. 30052 CO. NO. CO. NAME FRANKLIN
 A HANSON ENGINEERS INC. DAM SAFETY INSPECTION JOB # 79511

B 300 5

B1 5

J 1 7 1

J1 0.15 0.20 0.30 0.40 0.50 0.75 1.0

K 0 1 3 1

K1 INFLOW HYDROGRAPH COMPUTATION

M 1 2 0.10 0.10 1

P 0 25.6 102 120 130

T -1 -88

0.14

U2 0.10 0.06

X 0 -.1 2

K 1 2 4 1

K1 RESERVOIR ROUTING BY MODIFIED PULS AT DAM SITE

Y 1 1

Y1 1 102 -1

Y4 99 100 101 102 102.7 103 104 105

Y5 0 2 39 188 355 442 808 1376

SA 0 9 10.5 11.5 19.3

SE 65 99 102.7 105 122.7

SS 99

SD 102.7 3.0 1.5 570

K 99

P.M.F. Input Data
 Sheet 5 Appendix C

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
 FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
 AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS						
				RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5	RATIO 6	RATIO 7
HYDROGRAPH AT	1	0.10	1	254.	339.	509.	678.	848.	1272.	1693.
	(	0.26)	(	7.20)	(	9.60)	(	14.40)	(	24.00)
ROUTED TO	2	0.10	1	32.	66.	155.	238.	320.	819.	1393.
	(	0.26)	(	0.92)	(	1.88)	(	6.74)	(	9.06)

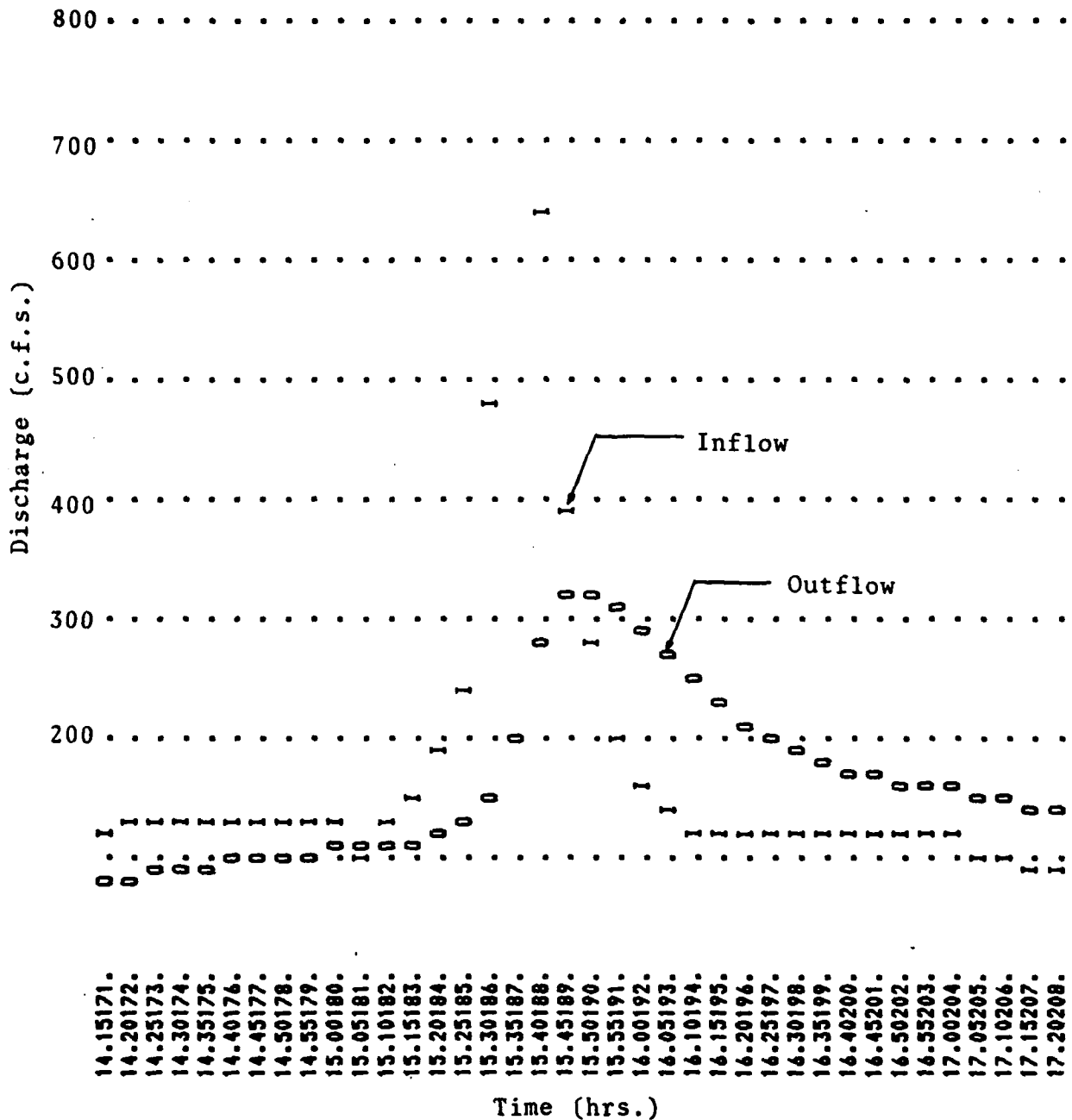
SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1							
ELEVATION		INITIAL VALUE		SPILLWAY CREST		TOP OF DAM	
STORAGE		99.00		99.00		102.70	
OUTFLOW		102.		102.		138.	
		0.		0.		353.	
RATIO	MAXIMUM	MAXIMUM	MAXIMUM	MAXIMUM	DURATION	TIME OF	TIME OF
OF	RESERVOIR	DEPTH	STORAGE	OUTFLOW	OVER TOP	MAX OUTFLOW	FAILURE
PMF	U.S.ELEV	OVER DAM	AC-FT	CFS	HOURS	HOURS	HOURS
0.15	100.82	0.00	119.	32.	0.00	17.08	0.00
0.20	101.18	0.00	123.	66.	0.00	16.00	0.00
0.30	101.78	0.00	129.	155.	0.00	15.83	0.00
0.40	102.21	0.00	133.	238.	0.00	15.83	0.00
0.50	102.55	0.00	137.	320.	0.00	15.83	0.00
0.75	103.05	0.35	142.	819.	0.50	15.67	0.00
1.00	103.32	0.62	145.	1393.	0.58	15.67	0.00

Sheet 6, Appendix C

Inflow - Outflow
Hydrograph
For 50% P.M.F.

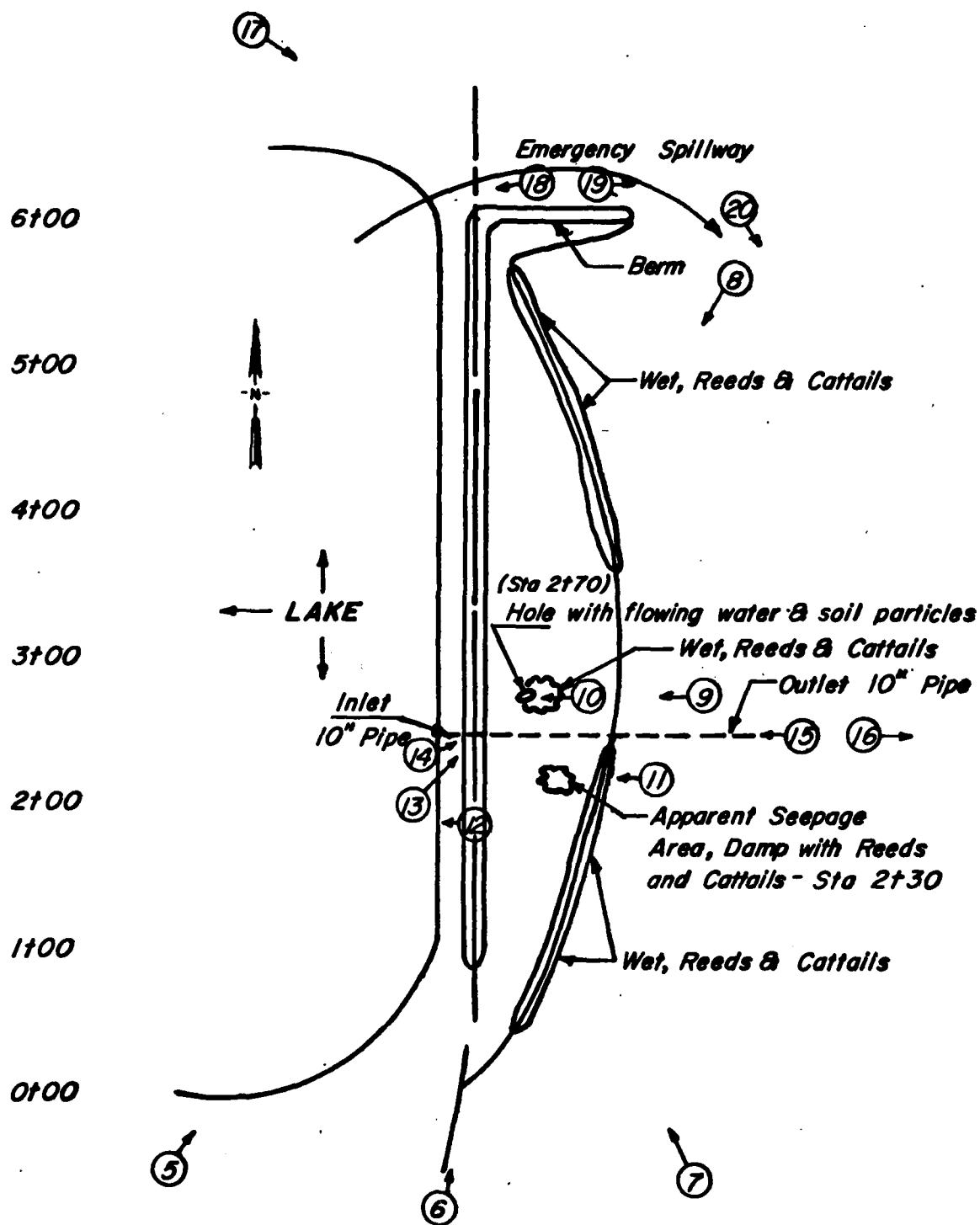
Max. Inflow = 848 c.f.s.
Max. Outflow = 320 c.f.s.



APPENDIX D

PHOTO INDEX

<u>Photo No.</u>	<u>Description</u>
1	Aerial - Looking North at Lake and Watershed
2	Aerial - Looking Northwest at Dam
3	Aerial - Looking West at Dam
4	Aerial - Looking North at Dam
5	Upstream Face of Dam From South Abutment
6	Crest of Dam From South Abutment
7	Downstream Face From South Abutment
8	North Downstream Contact - Note Reeds and Cattails at Toe
9	Seepage Area on Downstream Face at ±Station 2+70
10	Same Area as Photo 9 - Note Animal Hole with Water Carrying Soil Particles
11	Apparent Seepage Area on Downstream Face at Station 2+30
12	View of Lake From Crest of Dam
13	Primary Spillway Pipe Inlet
14	Primary Spillway Pipe Inlet
15	Primary Spillway Pipe Outlet - Looking Upstream
16	Primary Spillway Pipe Outlet Channel - Looking Downstream
17	Emergency Spillway Area at North Abutment
18	Emergency Spillway - Looking Upstream
19	Emergency Spillway - Looking Downstream
20	Emergency Spillway - Looking Downstream at Outlet Area



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 CHECKED DED
 DATE 7-19-79
 JOB NO. 7951L

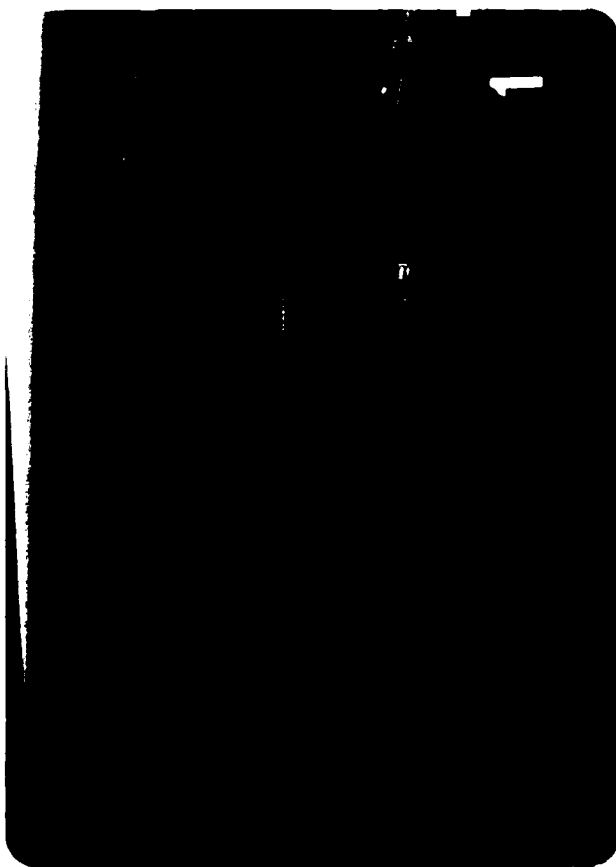


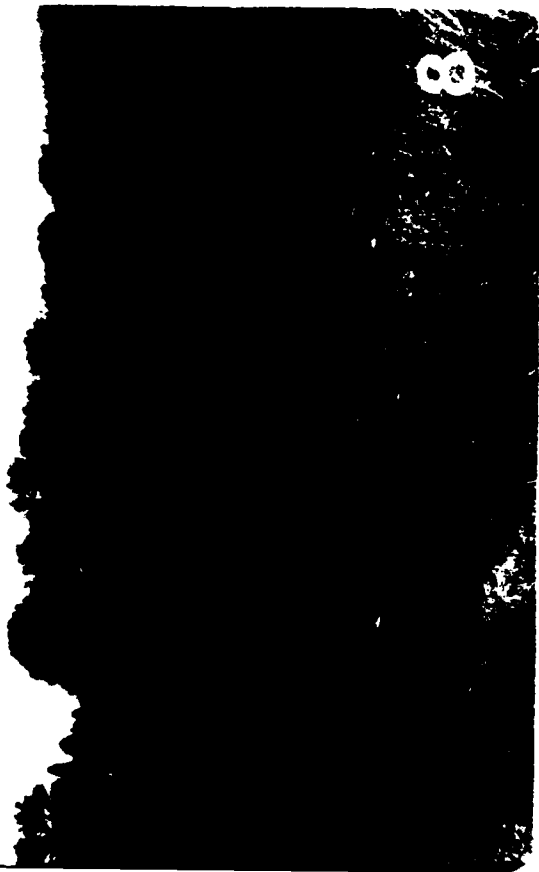
HANSON
ENGINEERS

SPRINGFIELD ILL.

PEORIA ILL.

Plan Sketch
 Key To Photographs
 Sheet 2 Appendix D











17



18



SUBJECT

LOCATION

OCCASION

AUGUST 1979 - EV

AUGUST 1979

SUBJECT

LOCATION

OCCASION

AUGUST 1979

SUBJECT

LOCATION

OCCASION

AUGUST 1979 - EV

AUGUST 1979

SUBJECT

LOCATION

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AUGUST 1979